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General Geology Report 62
1972

Upper Devonian Marine - Nonmarine Transition, Southern Pennsylvania

Roger G. Walker

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

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General Geology Report 62

Upper Devonian Marine - Nonmarine Transition, Southern Pennsylvania

by Roger G. Walker
McMaster University
Hamilton, Ontario

PENNSYLVANIA GEOLOGICAL SURVEY
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1972

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PREFACE

This field guide presents a concise interpretation of the development of part of the Devonian Catskill Delta in south-central Pennsylvania, together with graphic measured sections of the more continuous outcrops. The guide is directed toward all professional geologists, and particularly toward undergraduate and graduate students interested in stratigraphy, sedimentology, and the interpretation of ancient environments of deposition. The geologic interpretation in this report is different from that expressed in Pennsylvania Geological Survey Report G 63, *Stratigraphy, Sedimentology and Regional Correlation of Upper Devonian Rocks in Northeastern Pennsylvania.*

The measured sections have been keyed in to reference points such as road signs, drains, and telephone poles so that users of the guide can locate specific features easily. However, some of the road signs are moved occasionally!

The main controversial point of interpretation is the suggestion that in this area, the "Catskill Delta" was *not* a vigorously prograding sandy delta, but that the shoreline was rather quiet, with dominantly mud deposition – similar, perhaps, to the present day muddy shoreline of southwestern Louisiana.

The complete measured sections and field guide are presented here for the first time. The reader should refer to the papers by Walker (1971) and Walker and Harms (1971) for details of environmental interpretation.

Suggestions are made for planning a one-day or two-day field trip to see the rocks – the factual basis for the interpretation.

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Upper Devonian Marine - Nonmarine Transition, Southern Pennsylvania

by
Roger G. Walker

ABSTRACT

In the Susquehanna Valley area, the Upper Devonian Catskill clastic wedge can be considered in the following four parts, from bottom upward: turbidites, slope shales, repeated alternations of shallow marine and nonmarine beds, and alluvial fining-upward cyclothems. The turbidites are thin bedded, and pass upward gradationally into the slope shales. These in turn pass abruptly into nonmarine deposits with little evidence of nearshore sand deposition. After establishment of nonmarine conditions, there were about 20 alternations from marine sandstones and shales (with brachiopod and crinoid debris) to nonmarine red siltstones (with rootlets, desiccation cracks and calcareous nodules). These repeated alternations are again characterized by the scarcity of sand near the shoreline.

The sequence in the Lehigh Valley area differs, in as much as the thin turbidites pass upward into thick (nearer to source) turbidites. Slope shales are not present, and shallow marine deposits are, in places, cut out by deep (distributary?) channels. After establishment of nonmarine conditions for the first time, there was only one marine-nonmarine alternation; an alluvial environment with meandering rivers was rapidly established.

Thus the "Catskill Delta" quickly prograded westward past the Lehigh area, but sand was trapped on the newly-constructed alluvial plain. Consequently, in the Susquehanna area, the shoreline was mainly muddy.

Details of this interpretation and graphic measured sections intended for use in the field are included in this field guide, together with suggestions for a one-day or two-day excursion.

INTRODUCTION

The purpose of this publication is first, to describe (with graphic measured sections) a portion of the Upper Devonian Catskill clastic wedge, and second, to provide a field guide to these rocks.

The stratigraphic interval includes parts of the Trimmers Rock and Catskill Formations, embracing the portion of the section from the incoming of turbidites into the Upper Devonian basin to the establishment of nonmarine alluvial plain conditions. The sequence, up to 900 m thick in the Susquehanna Valley, is essentially regressive but contains a series of minor transgressive-regressive lithofacies sequences associated with shoreline sedimentation.

The area studied is in south-central Pennsylvania, between the Lehigh and Susquehanna Rivers. Only those sections which have almost complete exposure through the stratigraphic interval defined above are discussed in detail (Figs. 1 and 2). Recent descriptions and interpretations of these rocks have been given by Walker (1971) and Walker and Harms (1971); bibliographies of earlier work are contained in these two papers.

In this guide, a brief resume of the basin model will be given. The main emphasis will be placed on the complete measured sections (not published elsewhere) and the field guide. The interpretations of basin development are not necessarily those of the Pennsylvania Geologic Survey, but the stratigraphic nomenclature follows that of the Survey.

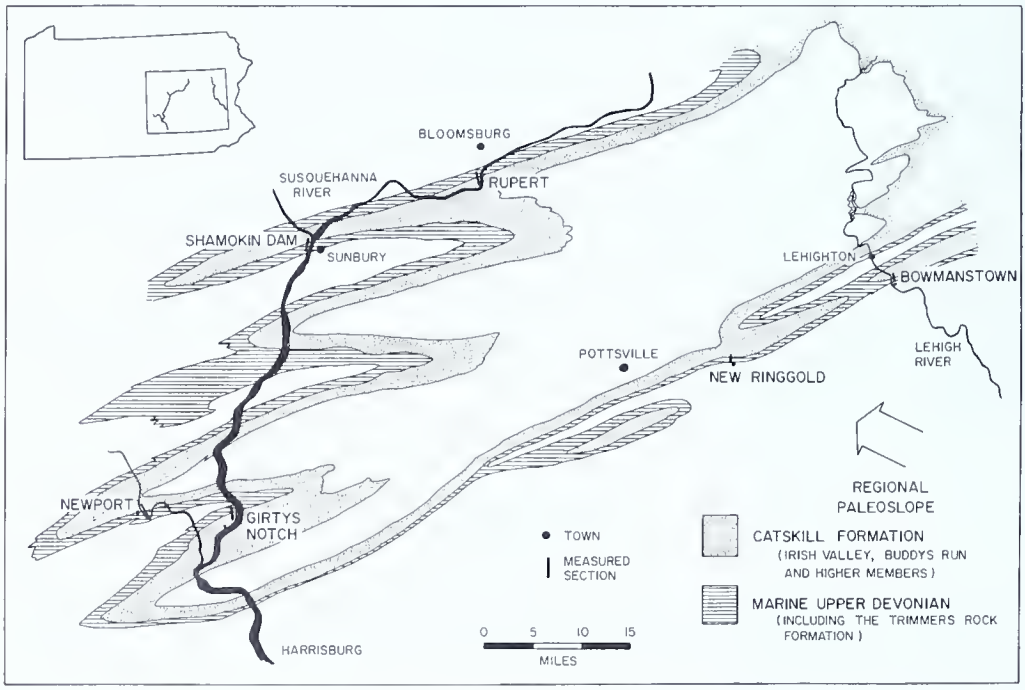

Figure 1. Locality map.

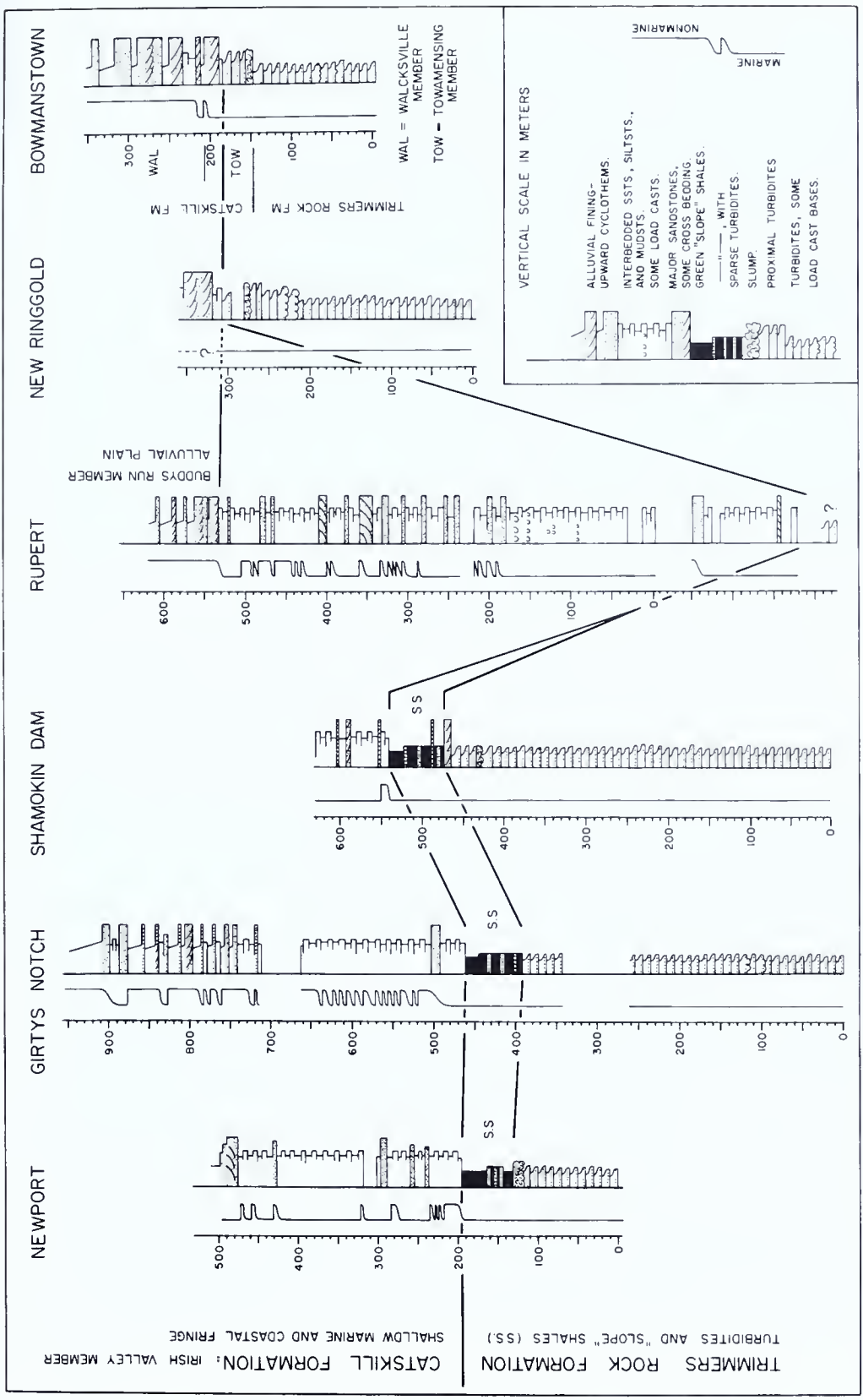

Figure 2. General correlation of lithofacies in the six measured sections. These lithofacies boundaries coincide generally, but not always in detail, with the stratigraphic boundaries. See the enclosed measured sections for accurate location of stratigraphic boundaries; for the Bowmanstown section, the stratigraphic and lithofacies boundaries have been shown.

SUMMARY OF THE UPPER DEVONIAN BASIN IN SOUTH-CENTRAL PENNSYLVANIA

SUSQUEHANNA VALLEY AREA

In the Susquehanna Valley area, the stratigraphic section embraced in this report can be interpreted in four parts, which are from bottom upward: turbidites, slope shales, Irish Valley "motifs" (repeated facies sequences) and alluvial fining-upward cyclothems. Justification for these interpretations has been given elsewhere (Walker, 1971; Walker and Harms, 1971) and will not be repeated here.

The turbidites are up to about 450 m thick, but individual beds are rather thin (Fig. 3), and the entire sequence has a dominantly distal aspect (i.e., far from the source of the turbidity currents; Walker, 1967). At the top of the turbidite sequence there is a slumped facies (Newport, Shamokin Dam) of disoriented sandstone balls in a shale matrix (Fig. 4), and this passes upward into about 40-60 m of green fissile shales. These are interpreted as slope deposits, because they occur stratigraphically between the turbidites and the shallow agitated-water beds. In some sections, there are rare turbidite beds within the slope facies, but the bulk is fissile shale with some brachiopods and crinoidal debris.

The top of the shale sequence passes rather suddenly into the first red beds with rootlets. At Shamokin Dam the change is gradational, but takes place within 2 m (Fig. 5); at Newport, the change is gradational, but is accomplished in more than 9 m (Fig. 6). The surprising aspect of the change from marine shales to nonmarine red siltstones (with rootlets and desiccation cracks) is the absence of winnowed sand bodies in this nearshore position. Only in the Girtys Notch section is there a sand body thicker than 1 m, so in all other areas the shoreline and nearshore area appears to have been sand-free; that is, without offshore bars, barriers, beaches and other winnowed accumulations. This pattern of a sand-free shoreline and nearshore area is repeated constantly higher in the section.

The 400-500-meter Irish Valley Member of the Catskill Formation proved to be the most difficult to understand during field work. The junction with the underlying slope shales has been discussed. The bulk of the Irish Valley Member consists of alternating marine, green, fissile shales with brachiopods and crinoidal debris, and red siltstones and mudstones with rootlets, desiccation cracks, and calcareous nodules. Careful examination showed that the marine-nonmarine alternations followed a regular pattern, and the entire 400-500 m can be discussed in terms of a repeated "Irish Valley motif"* (Fig. 7).

*The term "motif" implies a "constituent feature" or "dominant idea." It embodies both description and interpretation and avoids some of the rigid connotations of a definite sequence of facies implied by alternative terms such as "cyclothem"; see Walker and Harms, 1971.

Figure 3. Distal turbidites, at 40-60 m, Girtys Notch. Stratigraphic top to left.

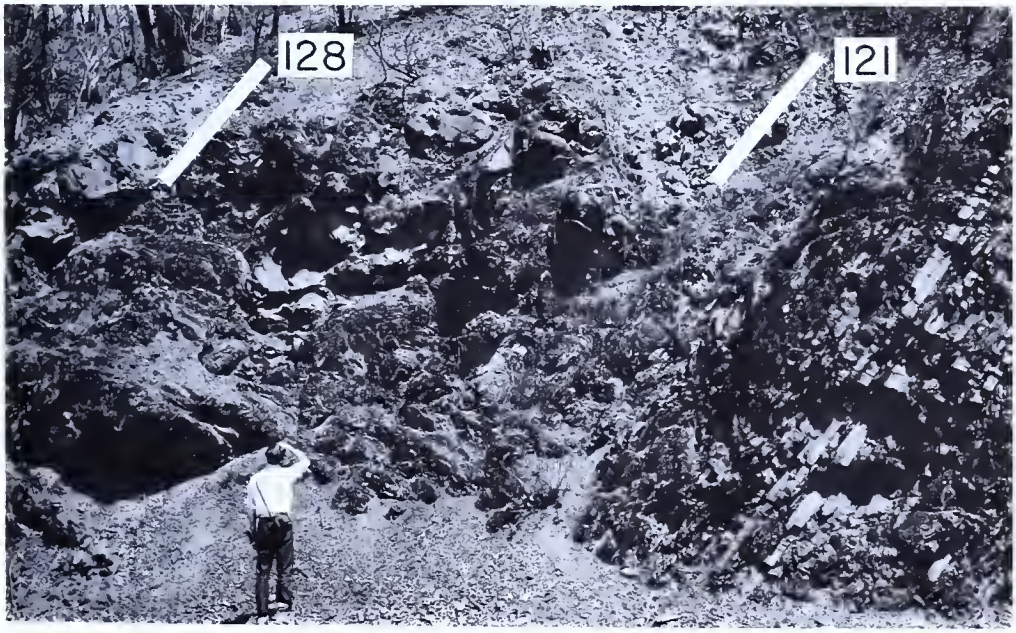

Figure 4. Slump horizon, 121-128 m, at Newport. Note parallel-bedded turbidites below slump, and lack of orientation of sandstone balls within slump.

Figure 5. Transition from greenish marine banded silty mudstones (up to 536 m) into reddish siltstones with rootlets and desiccation cracks (beginning at 537 m). About 12 m of rock show in the photo, with stratigraphic top to right.

Figure 6. Transition from marine shales (up to about 197 m) into the first red sandstones with rootlets (at 202 m) at Newport. Note that the *first* sandstone bed in the section bears rootlets, and that there are no marine nearshore or coastal sand bodies.

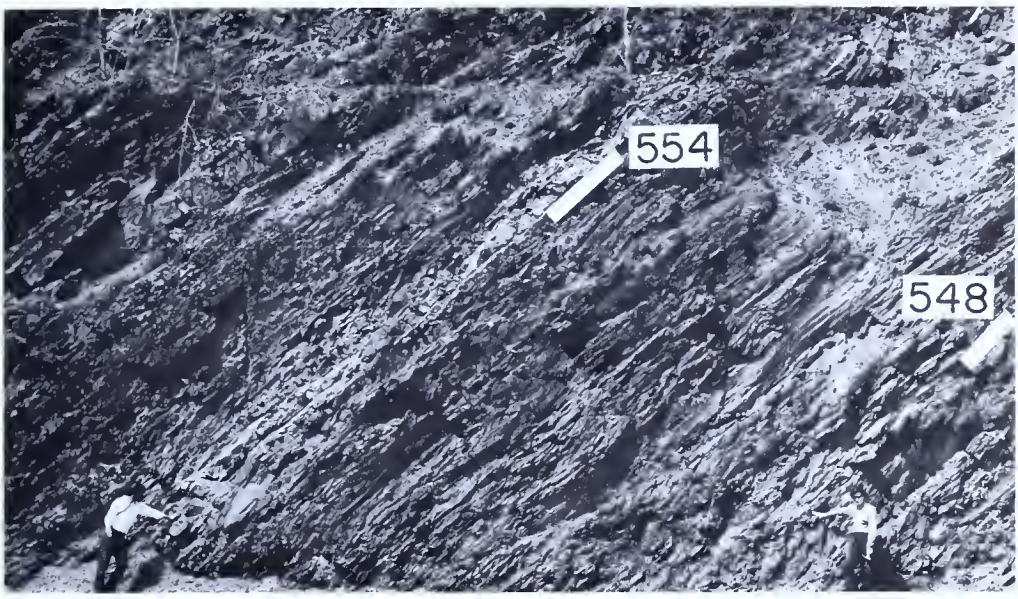

Figure 7. A complete Irish Valley motif, from 548 to 554 m, Girtys Notch. Both geologists in photo are resting their hands on bioturbate sandstone layers. Note the absence of sand bodies between the marine mudstones (548-549 m) and the nonmarine siltstones (550-554 m).

An ideal "motif" is shown in Figure 8, and details of individual motifs are shown in the measured sections. It can be seen that the marine portion of the motif consists of a transgressive bioturbate sandstone (Fig. 9), followed by green fissile shales with rare brachiopods and crinoidal debris. The nonmarine portion consists of red mudstones and siltstones, with small amounts of sandstone, characterized by traces of rootlets (Figs. 10 and 11), desiccation cracks (Fig. 12), and caliche-like calcareous nodules. In Figure 11, the irregular knobbly surface covered with hematitic markings is believed to be a breakage plane through closely spaced roots. These planes bear no regional relationship to cleavage or jointing.

In most of the motifs (see measured sections), sand bodies thicker than 1 m are absent from the shoreline area (Fig. 13), again suggesting either the absence of a sand supply or the ineffectiveness of waves to winnow sand into bars and beaches. The shoreline implied by the motifs is a rather quiet, muddy one (Fig. 14). During longshore drift of mud and silt, the shoreline prograded, building up a motif. During a period of reduced supply, the shoreline was attacked by the waves, and a thin winnowed transgressive sand was developed. Renewed supply by longshore drift caused another motif to develop. This model has been examined in detail by Walker and Harms (1971), and a close similarity to the present day prograding muddy shoreline of southwestern Louisiana has been documented.

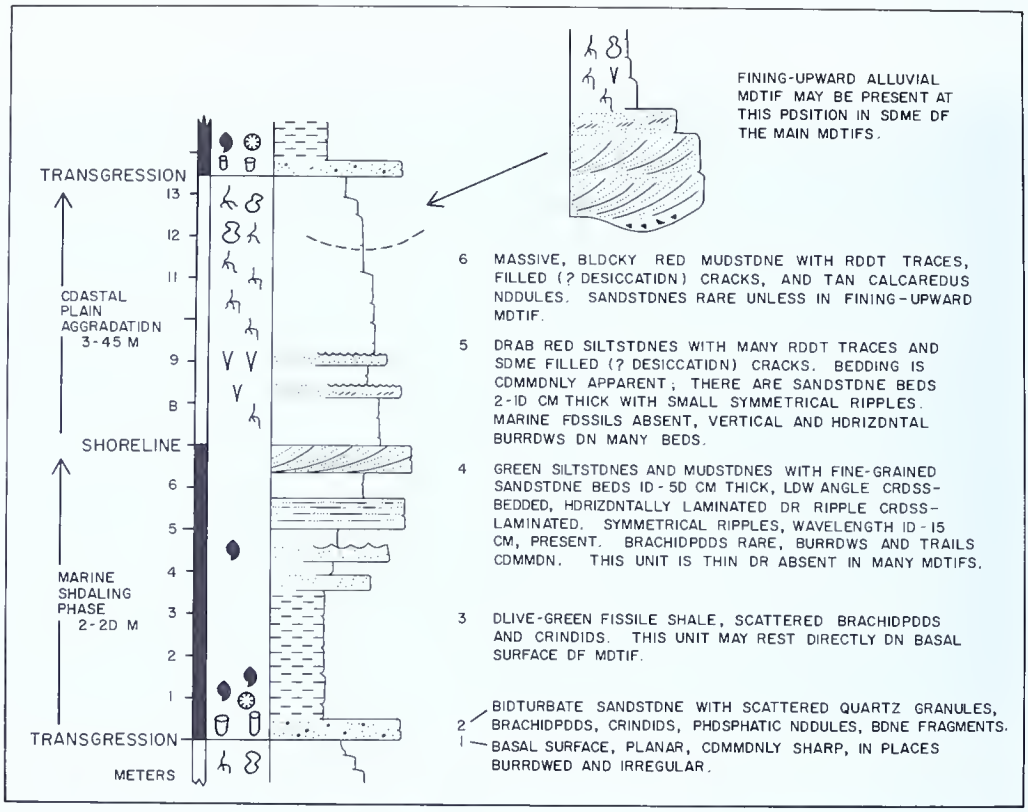
TRANSGRESSION
13
12
11
CDASTAL PLAIN AGGRADATIDN 3-45 M
9
8
SHORELINE
6
5
4
MARINE SHDALING PHASE 2-2D M
3
2
1
TRANSGRESSION
METERS
FINING-UPWARD ALLUVIAL MDTIF MAY BE PRESENT AT THIS PDSITION IN SDME DF THE MAIN MDTIFS.
6 MASSIVE, BLDCKY RED MUDSTDNE WITH RDDT TRACES, FILLED (? DESICCATIDN) CRACKS, AND TAN CALCAREDUS NDDULES. SANDSTDNES RARE UNLESS IN FINING-UPWARD MDTIF.
5 DRAB RED SILTSTDNES WITH MANY RDDT TRACES AND SDME FILLED (? DESICCATIDN) CRACKS. BEDDING IS CDMMDNLY APPARENT; THERE ARE SANDSTDNE BEDS 2-ID CM THICK WITH SMALL SYMMETRICAL RIPPLES. MARINE FDSSILS ABSENT, VERTICAL AND HDRIZDNTAL BURRDWS DN MANY BEDS.
4 GREEN SILTSTDNES AND MUDSTDNES WITH FINE-GRAINED SANDSTDNE BEDS ID-5D CM THICK, LDW ANGLE CRDSS-BEDDED, HDRIZDNTALLY LAMINATED DR RIPPLE CRDSS-LAMINATED. SYMMETRICAL RIPPLES, WAVELENGTH ID-15 CM, PRESENT. BRACHIDPDDS RARE, BURRDWS AND TRAILS CDMMDN. THIS UNIT IS THIN DR ABSENT IN MANY MDTIFS.
3 DLIVE-GREEN FISSILE SHALE, SCATTERED BRACHIDPDDS AND CRINDIDS. THIS UNIT MAY REST DIRECTLY DN BASAL SURFACE DF MDTIF.
2 BIDTURBATE SANDSTDNE WITH SCATTERED QUARTZ GRANULES, BRACHIDPDDS, CRINDIDS, PHDSPHATIC NDDULES, BDNE FRAGMENTS.
1 BASAL SURFACE, PLANAR, CDMMDNLY SHARP, IN PLACES BURRDWED AND IRREGULAR.

Figure 8. The Irish Valley motif.

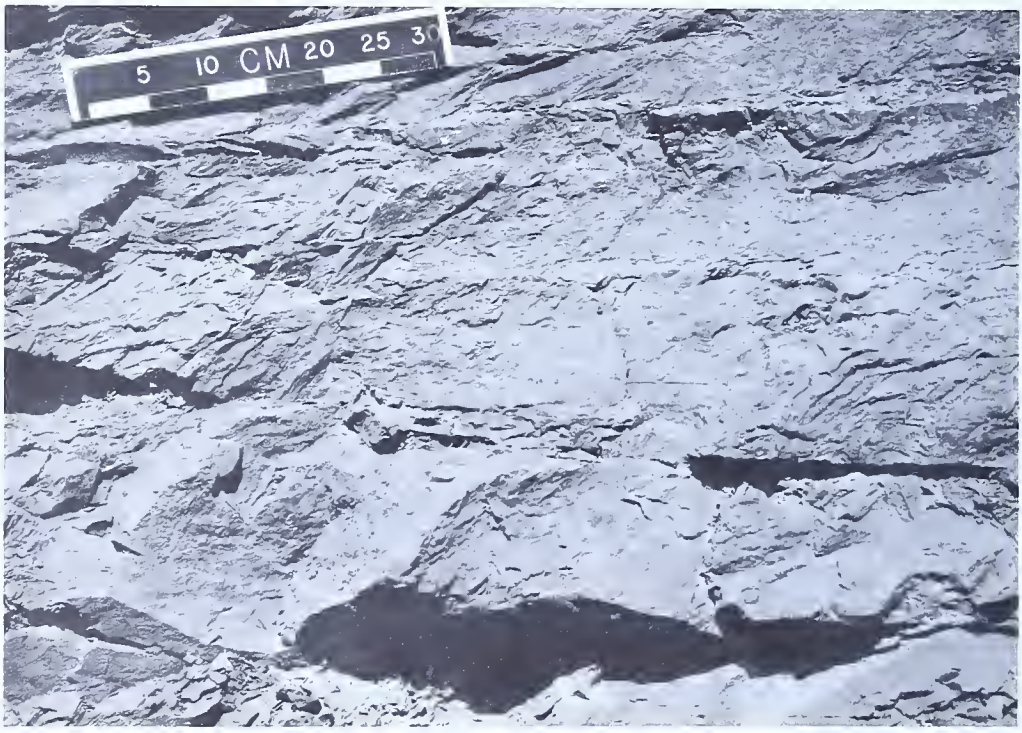

Figure 9. Bioturbate grey-green sandstone, from above heavy shadow to just below ruler. Below heavy shadow are massive red siltstones and just below ruler a 2-3 cm layer of brachiopod shells can be seen. Girtys Notch, 774 m. (Photo. courtesy of J. C. Harms).

Figure 10. Rootlets, branching downward, and showing up as hematitic glossy markings on the dull siltstone surface. Width of photo about 14 cms.

Figure 11. Plan view (sunlight, below tape) and vertical cross section (partly shaded, below tape) of a "knobbly surface." These surfaces typically are covered with hematitic glossy markings, and bear no relationship to cleavage or joint surfaces. The knobbly surfaces are believed to represent breakage planes among closely spaced roots.

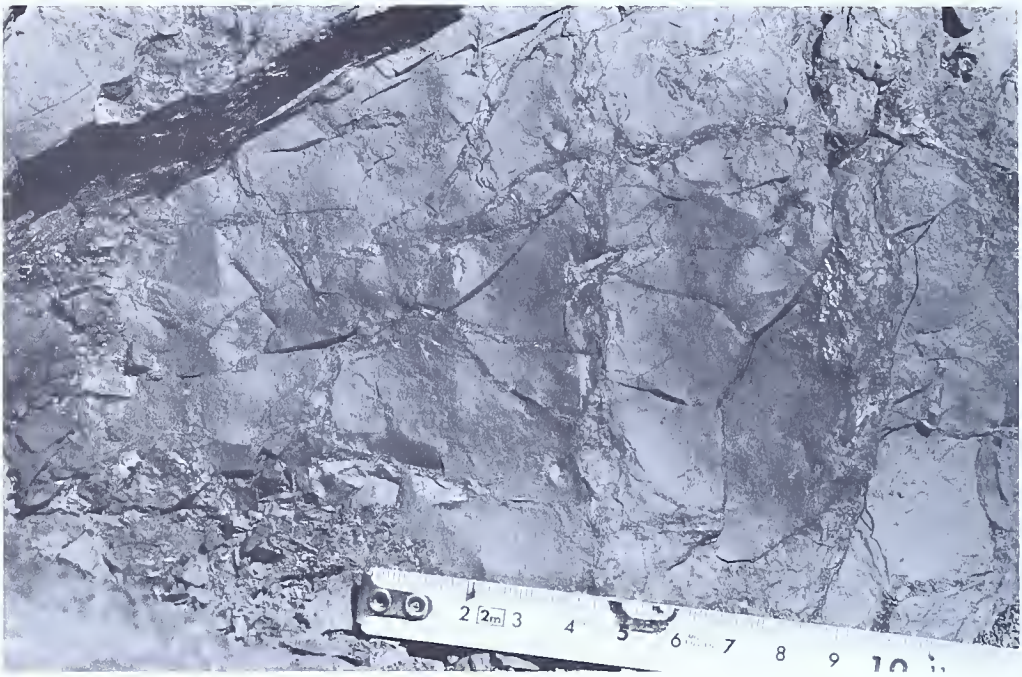

Figure 12. Silt-filled desiccation cracks on an originally muddy surface. Note that the cracks are sharp-edged and relatively straight; these features allow cracks to be distinguished from horizontal rootlets (fuzzy edged, sinuous) with some confidence.

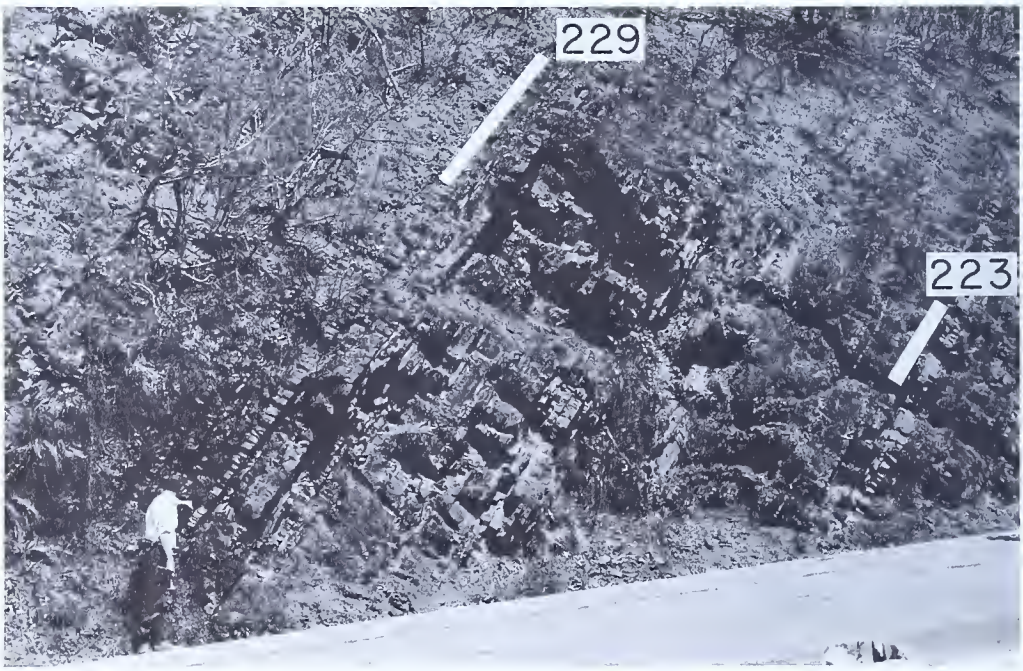

Figure 13. Irish Valley motif at Newport, 223-229 m. Note absence of major sand bodies within motif, implying a muddy shoreline.

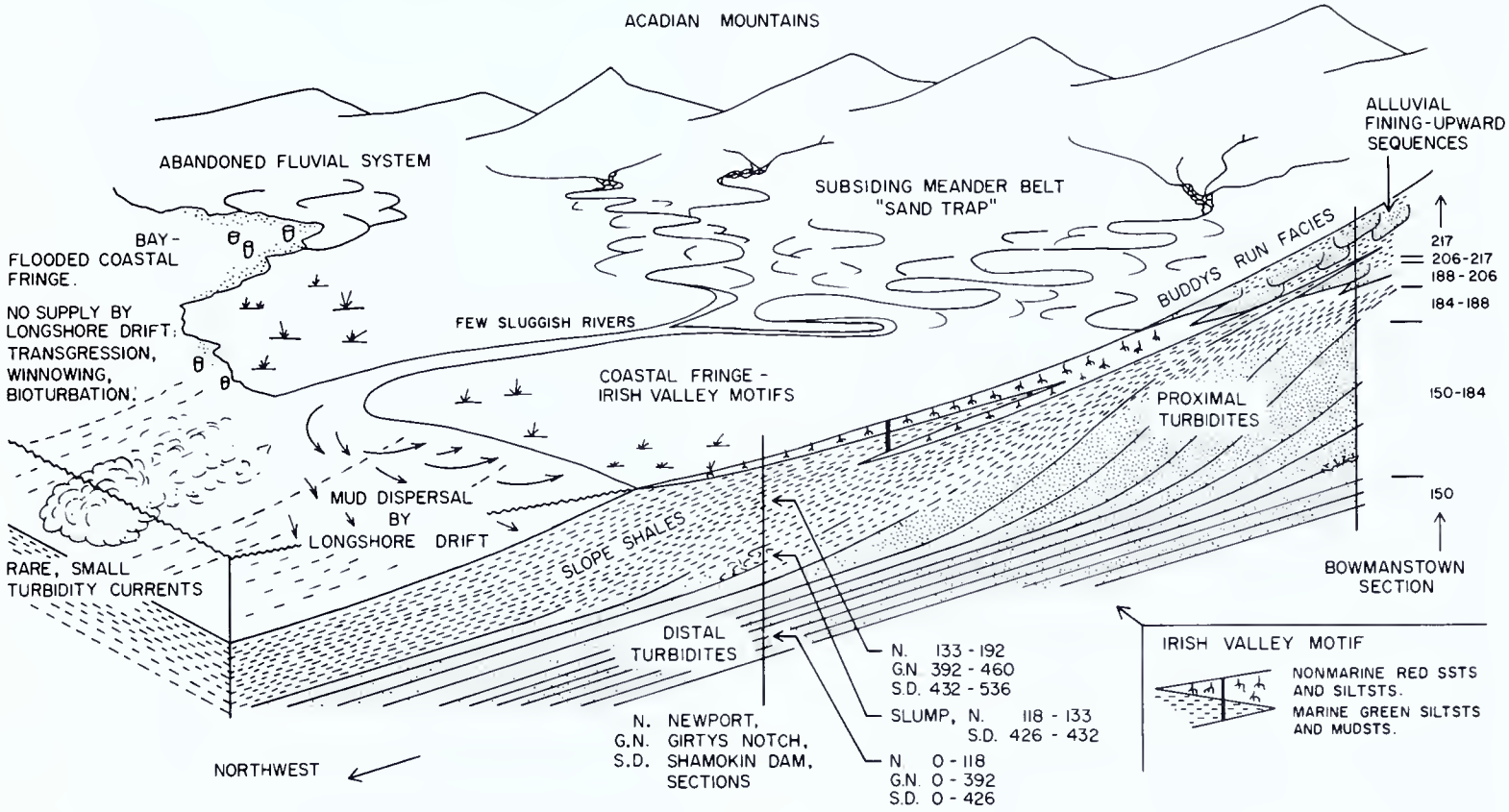

Figure 14. Reconstruction of Catskill paleogeography when the shorelines stood in the Susquehanna Valley area. Width of coastal fringe perhaps about 10-30 miles, and palinspastic distance from Bowmanstown to Newport-Girtys Notch area down the paleoslope about 40-50 miles.

In the nonmarine portions of some motifs there are alluvial fining-upward cyclothems of the type developed by meandering rivers (Fig. 15). These rivers were probably small, local streams draining the floodplain rather than the main trunk streams which supplied large volumes of sediment to the shoreline.

Above the last marine transgression, the sequence passes into the Sherman Creek Member of the Catskill Formation (in Walker, 1971, p. 1307, the term "Buddys Run Member" was used for the beds now divided in some areas of the Susquehanna Valley into the Sherman Creek and Duncannon Members). This member consists of alluvial fining-upward cyclothems, and records the establishment of a floodplain environment without the influence of periodic marine transgressions.

In summary, the basin filling sequence in the Susquehanna Valley area consists of turbidites followed upward by slope shales. These shales pass rapidly into the first red beds, with very little evidence of nearshore winnowed sand accumulations. After deposition of the first red beds, green marine shales and red nonmarine siltstones and mudstones alternated in the Irish Valley motifs. Again, winnowed sand accumulations are normally absent in nearshore and shoreline positions, suggesting a dominantly muddy shoreline. After the last marine transgression, a floodplain with meandering streams was established (Fig. 14).

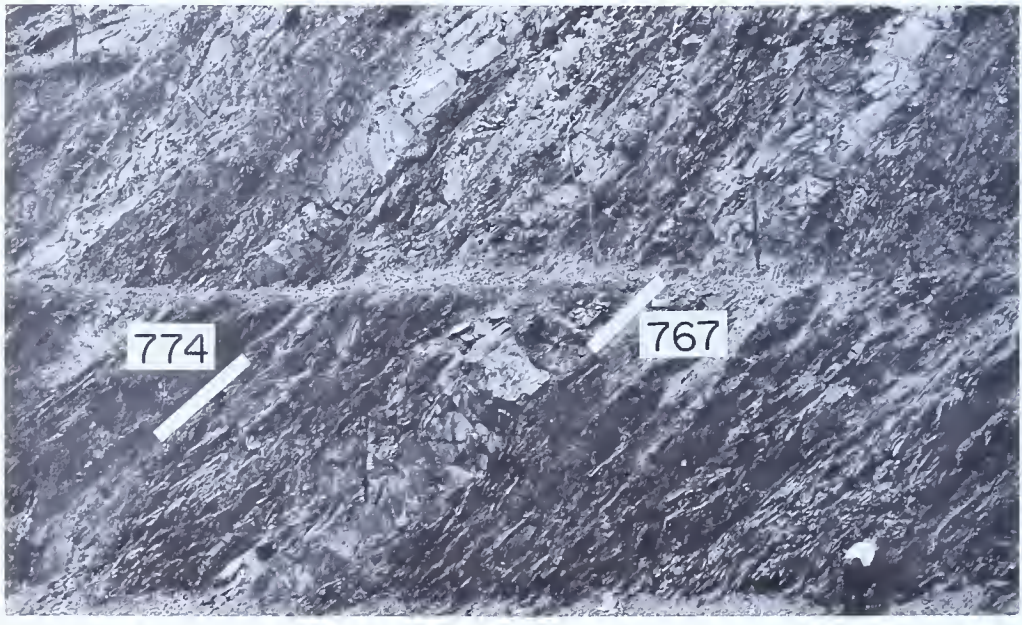

Figure 15. Irish Valley motif at Girtys Notch, defined by bioturbate sandstones at 757 and 774 m. The marine portion (757-759 m) is followed by a thick nonmarine portion (no nearshore or coastal sand body). Within the nonmarine portion there is a fining-upward sequence, beginning at 767 m, of fluvial origin.

The most important point of interpretation concerns the quiet, muddy shoreline, because this does not fit very well with preconceived ideas of a Catskill "delta." The evidence lies in the Irish Valley "motifs." The best places to observe the motifs are detailed in the field guide.

LEHIGH VALLEY AREA

The stratigraphic nomenclature and the lithofacies sequence are different in the Lehigh Valley area (Table 1). The stratigraphic nomenclature is shown on the measured sections. The lithofacies sequence at Bowmanstown is shown below:

Alluvial plain cyclothems
One "Irish Valley" motif
Proximal turbidites
Distal turbidites

Table 1. *Comparison of the Lehigh Valley and Susquehanna Valley Stratigraphic Sequences*

LEHIGH (Bowmanstown)	SUSQUEHANNA
1. Distal turbidites pass upward into proximal turbidites.	Distal turbidites do *not* pass upward into proximal turbidites.
2. No preservation of slope-shale facies.	Considerable development and preservation (up to 60 m) of slope-shale facies.
3. Very quick passage from marine to nonmarine rocks, with no shelf facies preserved. Shoreline sandstones interpreted as distributary channel deposits; no beaches are recognized.	Relatively quick passage from marine to nonmarine environment at top of slope, with little or no evidence of preserved shelf facies and scarcity of nearshore sand bodies.
4. Nonmarine conditions dominant after they were first established — there is only one brief return to marine conditions.	Above the slope shales, the section alternates from marine to nonmarine for about 600 m. In the regressive Irish Valley motifs, there is little evidence of nearshore sand bodies.
5. Nonmarine fining-upward sequences very thick (30 m), with high proportion of sand (about 67 percent of the sequence).	In the nonmarine portions of the Irish Valley motifs, fining-upward sequences are uncommon. Where identified, they are thin (11 m) and composed dominantly of fines (60 percent of the sequence). The thinner sands are finer grained than those in the Lehigh area.

The thin distal turbidites grade upward into thicker, more massive beds (Fig. 16) interpreted as proximal turbidites (see the description of the Bowmanstown section for details). Unlike the Susquehanna sections, there is no preserved slope shale, and the first shallow agitated-water clean sandstone occurs only 3-4 m above the last turbidite (Fig. 17). This clean sandstone occurs at the base of a fining-upward sequence which terminates in red siltstones with rootlets; the entire fining-upward sequence is possibly a distributary or estuarine channel fill. In contrast with the Susquehanna sections, there is only *one* marine transgression, and hence only one Irish Valley motif at Bowmanstown. The alluvial floodplain was rapidly and permanently established, with thick meandering-river sand bodies alternating with overbank siltstones and mudstones with rootlets and desiccation cracks (Fig. 18).

There is some disagreement concerning the development of the sequence in and close to Bowmanstown. In the section studied by J. D. Glaeser (pers. commun.) on route U.S. 209 just east of the turnpike exit, there is a much better development of shallow marine facies than at Bowmanstown. However, there is no slope-shale development (similar to that in the Susquehanna area) in either the route U.S. 209 or the Bowmanstown section. It seems probable that the shallow marine section, if it were originally present at Bowmanstown, has been eroded prior to deposition of the large sand body (188-202 m) here interpreted as a channel fill.

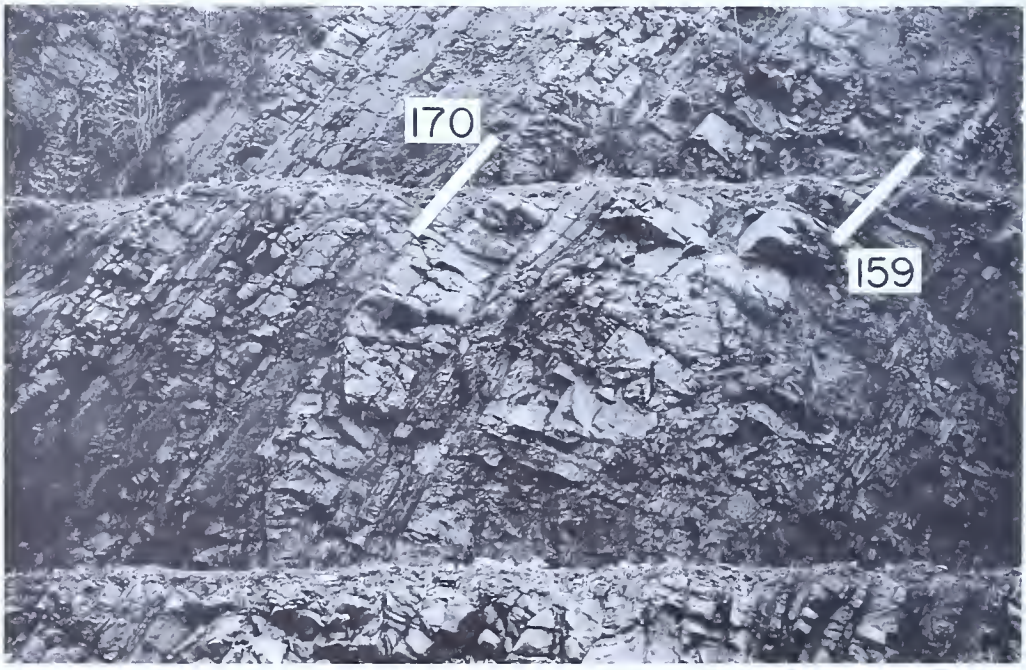

Figure 16. Proximal turbidites, with particularly thick composite beds between 159 and 170 m at Bowmanstown. Stratigraphic top to left.

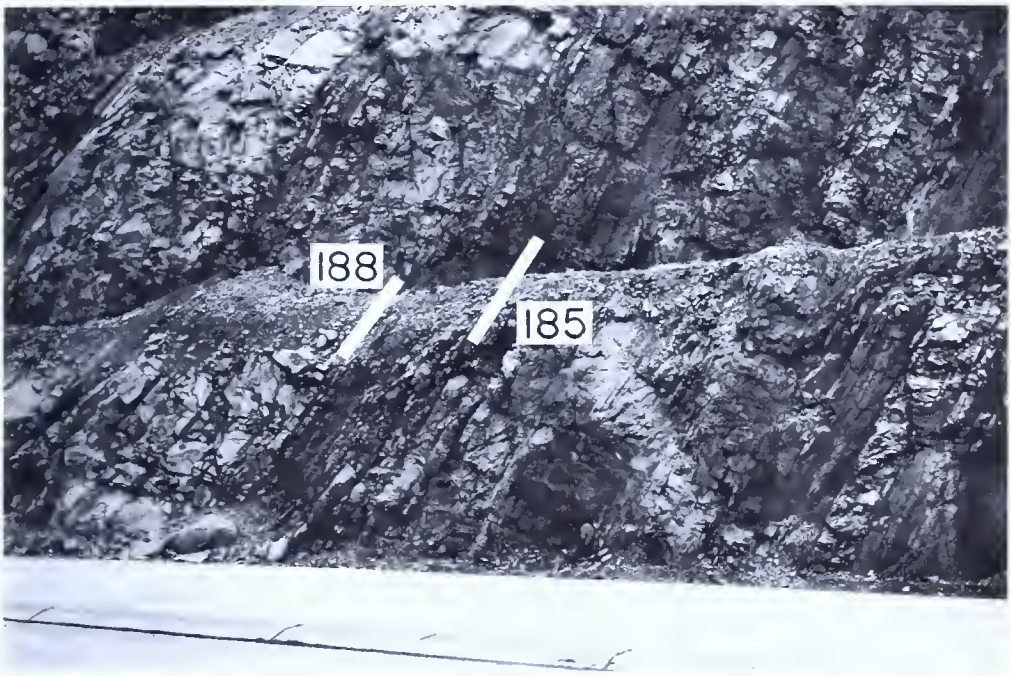

Figure 17. Transition from turbidites (up to 185 m) into clean quartzitic sandstones (beginning at 188 m) at Bowmanstown. Stratigraphic top to left.

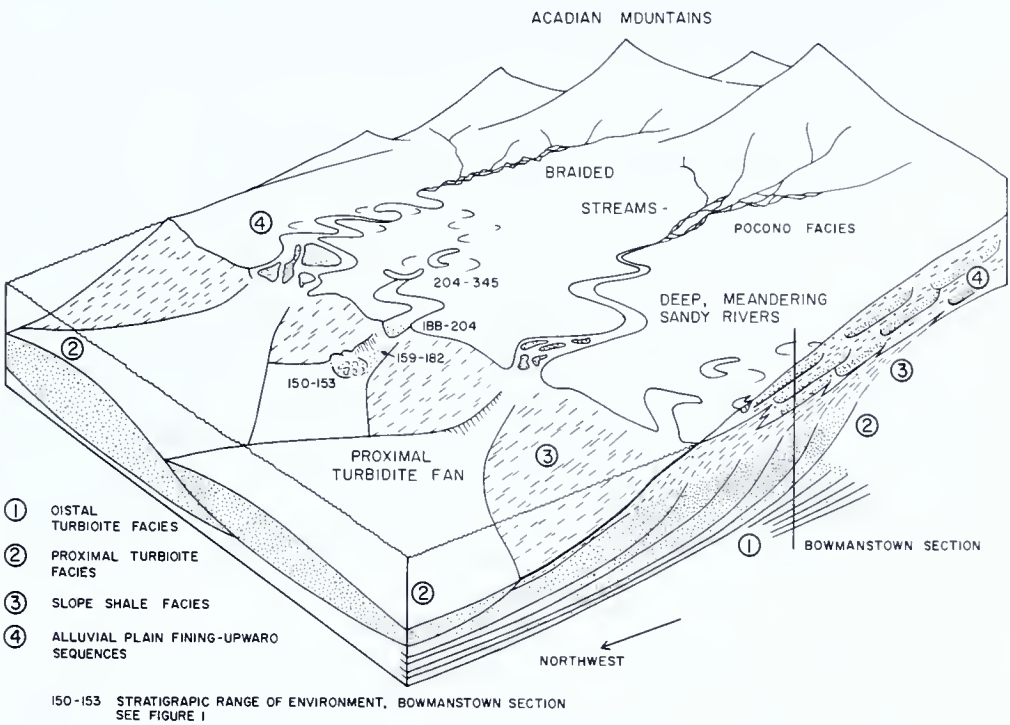

Figure 18. Reconstruction of Catskill paleogeography when the shoreline stood near Bowmanstown. Distance from Bowmanstown to mountains unknown, probably several tens of miles.

An interpretation of the facies of the Lehigh area is given in Figure 18. This diagram could possibly be redrawn to show the new data of J. D. Glaeser for shallow water deposition, but this data has not yet been published.

A comparison of Figures 18 and 14 shows the postulated changes in the depositional patterns during westward progradation. A full discussion of these changes has been given by Walker (1971) and Walker and Harms (1971). The essential difference is the development of a wide coastal plain which acts as a "sand trap," resulting in a muddy shoreline in the west, and the absence of thick "proximal" turbidites in the upper parts of the Susquehanna Valley sections.

CATSKILL "DELTA"?

The facts and interpretations presented above do not substantiate the idea that the Catskill in south-central Pennsylvania is a "delta." A delta may be considered a "*river-fed* depositional system that results in an irregular progradation of the shoreline" (Scott and Fisher, 1969), but the Irish Valley Member must be considered a longshore-drift-fed, muddy depositional system more akin to the muddy coastlines of southwestern Louisiana or parts of northern Venezuela.

Although this conclusion is contrary to the pictures of the Catskill Delta given in textbooks, the facts are well exposed in the rocks. It is hoped that the measured sections and the discussion of how the muddy shoreline conclusions were reached will stimulate geologists to revisit the Catskill clastic wedge and check the facts for themselves.

FIELD GUIDE TO INDIVIDUAL MEASURED SECTIONS

NEWPORT

Access

The section is exposed on the east side of the Juniata River, along the *old* highway 22/322 (this number is now assigned to the new expressway). The highway is next to the river, and the outcrops are opposite the town of Newport. The gap in outcrop, 300-315 m, represents the position of the highway from the town of Newport across the bridge and up to the new expressway. From the expressway, take the Newport exit to the east end of the bridge.

Comments on the Measured Section

Turbidites are exposed from 0 to 120 m; the zero mark is the end of outcrop, but is probably not the actual base of Trimmers Rock turbidites. From 120-130 m, a distorted, disoriented set of sandstone balls is embedded in a muddy matrix, and is overlain by bedded, load-deformed turbidites

(128-130 m). In the section 130-170 m, turbidites become sparse and die out upward. Exact thicknesses cannot be determined because of two folded and faulted horizons. The section 170-193 m consists of fissile green shales. There is then a very rapid passage into red siltstones with rootlets at 202 m. The base of the Catskill Formation, Irish Valley Member, is placed at the color change at 198 m.

From the rootlets at 202 m to the end of the well-exposed section at 495 m, Irish Valley motifs are exposed. The marine portions of two of them are unusually thick (234-272 m and 322-415 m), and only the proposed marine transgression at 217 m lacks a marine fauna. Here, the fissile green shale is considered diagnostic of transgression; slumped material makes the actual contact hard to see. Digging has not yet revealed a marine fauna. Above 478 m, the section is nonmarine, but is poorly exposed.

Interpretation

Turbidites were deposited (0-120 m), and the disoriented layer of sandstone balls in a matrix of shale (120-128 m) indicates that there was then lateral movement of sediment (slumping) within the basin. Above the slump, turbidites rapidly died out, and fissile green shales assigned to the upper parts of the slope were deposited. From the slope, there was a very rapid transition into nonmarine conditions (202 m), and then progradation of a muddy shoreline, alternating with marine transgressions (two of them very extensive), gave rise to a series of Irish Valley motifs. Marine transgressions of the floodplain finally ceased between 480 and 490 m.

GIRTYS NOTCH, NEW BUFFALO

Access

The section is exposed on the west side of U.S. 11/15 about 17 miles north of Harrisburg and 3 miles north of New Buffalo. The top of the section, 950 m, is about one-half mile north of the "Trail Diner," and the foot of the section (0 meters) is placed at the major incoming of turbidites above a dominantly shaly section. These turbidites are exposed immediately south of a short wooded section about one-half mile south of the roadside rest.

Comments on the Measured Section

The entire section is exposed in three parts, with two covered intervals. The section from 0 to about 300 m is exposed in the northernmost outcrop, and consists entirely of interbedded turbidites and shales. There are several beds which have been deformed by loading, but no true slumps. The section 300-340 m is covered; a small stream crosses under the highway, and there are a few houses in the valley.

The section 340-445 is dominantly shaly, with a few turbidite beds present. These become less abundant upward. There is no proximal facies, nor is there any evidence for slumping, although a few beds are deformed by loading. The section 445-460 m consists of fissile grey-green shales. Above 460 m, the style of deposition changes, and the base of the Irish Valley Member of the Catskill Formation is drawn at this point. The section 460-505 m indicates progressive increase in the amount of sand in the section, although the pelecypods at 467 m are thin-shelled pelagic forms *(Pterinea).* The big sand body, 492-503 m, contains four thin, fining-upward sequences at the top, and rootlets first appear at 508 m. The first marine transgression of Irish Valley type occurs at 513 m, and between 513 and 660 m, there are 15 marine horizons defining 15 Irish Valley motifs. The only places where marine transgressions are proposed on lithological grounds, with no marine fossils yet discovered, are at 524 and 586 m. The lithological criteria are discussed in the main text.

The covered interval from 660 to 710 m is occupied by the "Rock and Mineral House." Irish Valley motifs resume at 715 m, and 6 marine horizons, all with marine faunas, are recognized. Within the *nonmarine* portion of the Irish Valley motifs in the 715-900 m section there are some well-defined fining-upward cyclothems, beginning at 741, 749, 767, 794, 809, 838, 854, 875 and 899 m. Above 899 m the section is entirely nonmarine, mainly massive siltstones and fine sandstones, and the sandstone base at 899 m is *tentatively* taken as the base of the Duncannon Member of the Catskill Formation.

Interpretation

Turbidity currents poured into the basin from 0-445 m, although in the section 340-445 m they became rather sparse, with no proximal facies nor any slumping developed. The shales from 445 to 460 m are placed at the upper part of the slope into the basin, and the gradual incoming of sand (460-503 m) indicates approach to the shoreline. Nonmarine conditions were established at 508 m, and the succeeding Irish Valley motifs indicate progradation of a muddy shoreline, alternating with episodes of marine transgression. The fining-upward sequences (beginning at 741, 749, 767, 794, 809, 834, 854, 875, and 899 m) indicate meandering streams on the floodplain in the nonmarine parts of the motifs. The floodplain appears to have become permanently established at 899 m, with no more marine transgressions.

SHAMOKIN DAM

Access

The section is exposed on the west side of the Susquehanna River, opposite the town of Sunbury. The measured part of the section (415-625 m) can be reached by driving north on U.S. 11 for about half of a mile from the

junction of U.S. 11 and U.S. 15 at "Tedd's Landing." Pass under the Reading Railroad bridge. At the foot of the bridge, a small track leads up to exposures on the Reading Railroad tracks. At the top of the track, the "pole between tracks" at 485 m and the "overhang" at 537 m are easily located. If the entire turbidite section is to be visited, park just north of "Tedd's Landing" on U.S. 11. The first exposure of turbidites in the railroad cut occurs at the zero meter mark for the measured section, and is close to the very shaly lower portion of the Trimmers Rock Formation.

Comments on the Measured Section

From 0 m to the bottom of the slump at 425 m there is continuous exposure of dominantly thin, laminated and cross-laminated turbidites (Bouma BC and C types). About 2400 individual beds have been measured, and trends in thickness, sand/shale ratio and *ABC index* are shown in Figure 7 of Walker, 1971. The disturbed section, 425-431 m, is interpreted as a slump, mainly because of the random, disoriented arrangement of sandstone balls within the matrix.

Turbidites continue to about 460 m, but above that point there is an important sedimentological change. The sandstone body from 462 to 470 m is better sorted and contains much less matrix than the turbidite sandstones below, and at the base it contains large-scale cross-bedding in pebbly sandstone. This unit is puzzling, because the section 470-484 m reverts to alternations of sharp-based, parallel-bedded sandstones and shales, interpreted tentatively as turbidites. A second, puzzling, clean sandstone occurs at 484-486 m, and is again followed by shales alternating with a few sharp-based, parallel-bedded sandstones, up to 520 m. Neither of these clean sandstone bodies would be expected within the turbidite sequence, but it would be even harder to interpret the shales and sandstones (470-484 and 486-520 m) if the first clean sandstone body (462-470 m) were interpreted to mark the beginning of constant basin agitation. This problem is discussed again in the interpretation below.

The section from 520 to 536 m is dominantly color-banded, greenish-grey, silty shales, marine at least as high as 522 m. Rootlets and desiccation cracks occur in the overhang at 538 m, indicating an astonishingly rapid transition from marine silty shales to nonmarine siltstones, with no development of a nearshore sand body. Rootlets and desiccation cracks persist to 547 m, where there is a bioturbate green sandstone with phosphatic nodules, followed by a fissile green shale. This is exactly the type of lithological association which indicates a marine transgression, but so far no definite marine fossils have been found. The next marine fossils occur at 595 m, and the section appears on sedimentological grounds to remain marine as far as 625 m, when outcrop is lost in the woods.

Sedimentologically, the major break between basinal shales and turbidites and the first establishment of nonmarine conditions occurs at 537 m. However, this may not be a good mapping horizon, and hence the stratigraphic junction

between the Trimmers Rock Formation and the Irish Valley Member may be placed at the base of the prominent sandstone at 462 m.

Interpretation

The section 0-426 m consists only of turbidites and basin shales. The slump (426-431 m) heralds a change in the basin, and turbidites gradually become less and less abundant (431-520 m). No proximal turbidite facies is developed. The two clean sandstone bodies stand out anomalously in this environment, and may represent localized areas of powerful traction currents on the sea floor – perhaps a submarine channel of some type. This interpretation seems preferable to one suggesting establishment of basinwide agitation at 462 m, because there is then the problem of interpretation of the sandstone-shale interbeds (470-484 and 486-520 m). However, interpretations between 462 and 537 m must be regarded as tentative.

Progradation of the muddy shoreline, with no sand winnowing, is recorded by the abrupt passage into nonmarine beds at 537 m. A marine transgression is proposed at 547 m, and the section remains marine until the end of outcrop. However, above 547 m there was general basin agitation, and there is no record of continued turbidity current activity. A rather muddy, shallow inundated coastal margin is envisaged.

RUPERT, NEAR BLOOMSBURG

Access

The Rupert section is exposed on the west side of Pennsylvania Highway 42, between Rupert and Catawissa. Pennsylvania Highway 42 can be reached directly from U.S. 11, or from the Bloomsburg exit of Interstate 80. The zero point on the section is at a roadside table one-half mile south of Rupert railroad station.

Comments on the Measured Section

The turbidite part of the sequence is exposed directly opposite Rupert railroad station, but exposures are patchy between the station and the roadside table. Immediately north of the roadside table is a stream and a dirt road off to the west, and immediately north of the track is a sandstone bluff with rootlets in the top. However, the section 0-130 m, and perhaps as high as 185 m, consists of marine siltstones with thin interbedded sandstones. Rootlets again appear at 190 m, and Irish Valley motifs are exposed between 192 and 530 m. Above 530 m, the section is entirely nonmarine, and from 530 to 570 m, and continuing almost into Catawissa, there are excellent exposures of fining-upward sequences. The stratigraphic contact of Irish Valley and Buddys Run is placed at 553 m because of the color change, although the major sedimentological break is at 533 m.

Some of the Irish Valley motifs have unusually thick marine portions (250-284 m, 360-399 m), and others contain unusually thick sandstone bodies (327-335 m, 346-363 m, 403-412 m). Other motifs are unusually thin (308-324 m), with rootlets only 1-2 m stratigraphically above marine faunas.

Interpretation

Turbidites were deposited in the basin (Rupert R. R. station), but inadequate exposures do not permit reconstruction of the passage into nonmarine conditions. The interbedded siltstones and sandstones (0-150 m) lack the graded bedding, organization of sedimentary structures and bedding regularity typical of turbidites, and are interpreted as shallow marine deposits. Rootlets at 190 m followed by a marine transgression at 192 m herald the development of Irish Valley motifs, some unusually thick and others unusually thin. The motifs only contain one fining-upward sequence, in the nonmarine portion (476-484 m). Continuous, nonmarine sedimentation begins at 533 m, and above there are about 16 well-developed fining-upward sequences, formed by lateral accretion in meandering rivers and vertical accretion on the adjacent floodplain, before the outcrop ends about one-half mile north of Catawissa.

BOWMANSTOWN

Access

The section is well exposed in high road cuts on the east side of Pennsylvania Highway 248, between Parryville and Bowmanstown, about 2½ miles southeast of Lehighton. The section 140-350 m is best reached by taking the Parryville exit from Highway 248. The lower turbidite part of the section is best reached from the southern end by taking the approach road from Bowmanstown to Highway 248.

Comments on the Measured Section

The zero mark is taken at the lowest exposed turbidite at the southern (Bowmanstown) end of the section. Most of the beds in the 0-140 m section are laminated or cross-laminated, Bouma BC and C types. A disturbed layer at 150-153 m is interpreted as a slump, although the possibility of tectonic disturbance cannot be ruled out. The section 153-182 m consists of very thick-bedded sandstones, all of which have considerable (more than 30 percent) matrix. From 182-185 m, there are some thin, well-graded, matrix-rich sandstones which are identical to the tubidites lower in the section (0-140 m). By contrast, the sand body which begins at 188 m contains almost no matrix, and has large-scale cross-bedding. It is suggested that the thick sandstones (153-182 m) are proximal turbidites because of their petrographic similarity to turbidites lower in the section, because of the turbidites immediately above

them (182-185 m), and because of the clear petrographic dissimilarity to the cross-bedded sandstone beginning at 188 m. The sedimentological change from basinal turbidites and shales to agitated shallow-water deposits therefore is compressed into the section 185-188 m.

The big sand body, 188-205 m, is marine in its lower part, but contains rootlets in the upper part – these represent the first establishment of nonmarine conditions. Immediately above the rootlets is a bioturbate pebbly sandstone with brachiopods, a typical marine transgressive layer. Rootlets reappear at 219 m, and the section remains nonmarine above this point. The nonmarine section can, in a general way, be divided into a series of fining-upward sequences, beginning sharply with sandstones at 234, 258, 281, 296 and 337 m.

The stratigraphic mapping units used by the Pennsylvania Geological Survey do not all follow the sedimentological breaks selected in this field guide. The base of the Catskill clastics (Towamensing Member) is drawn at 150 m, and the base of the Walcksville Member is drawn at 202 m. The latter represents the major change from marine to nonmarine sedimentation. Hence the Towamensing Member consists of both proximal turbidites and shallow-water clean sandstones.

Interpretation

The dominantly thin, Bouma BC and C type turbidites (0-150 m) are interpreted as relatively distal. By contrast, the thick beds (153-182 m) of matrix-rich sandstone are interpreted as proximal turbidites, deposited closer to the source of the turbidity currents. The sand body at 188-204 m is marine at the base and nonmarine at the top. The overall fining-upward sequence suggests that it may be a channel fill, perhaps a distributary channel. After the first establishment of rootlets at 205 m, there is only one reversal to marine conditions, and the bioturbate sand at 206 m is identical to the bioturbate layers at the bases of the Irish Valley motifs in the Susquehanna Valley. After reestablishment of nonmarine conditions at 218 m, there are about 5 thick fining-upward sequences, beginning at 234, 258, 281, 296 and 337 m. The sandy portion of these represents lateral accretion on point bars, and the silty portion represents vertical accretion on the adjacent floodplain by deposition of overbank fines. The high ratio of sandy to silty portions implies deep channels, and probably extensive erosion of earlier overbank fines by the succeeding channel.

The overall passage from turbidites to floodplain is very rapid, with no equivalent of the thick slope shales of the Susquehanna Valley area, and only one motif of the Irish Valley type.

NEW RINGGOLD

Access

The measured section is exposed about one-half mile north of New Ringgold, on the east side of Pennsylvania Highway 443. New Ringgold itself is

about 10 miles east of Schuylkill Haven (which is 4 miles south of Pottsville) on Highway 443.

Comments on the Measured Section

The section from 0 (the lowest exposed turbidite) to 260 m consists dominantly of thin Bouma BC and C turbidites. Many beds have load casts on the bases. The turbidites from 260 to 280 m are thicker, load casts are very common, and the unit from 275 to 278 appears slumped. The section 278-295 m is very poorly exposed or covered. From 295 to 300 m, load casted turbidites appear again, and from 300 to 319 m the beds have a transitional appearance, with much gioturbation, and some massive, greenish, silty sands of uncertain origin. A major break appears at 319 m, with the incoming of clean, pebbly reddish sands, taken to be the base of the Catskill clastics (Towamensing Member). From 333-360 m, the sandstones are very pebbly, and are characterized by trough cross-bedding. It is not clear whether they are marine or nonmarine.

Interpretation

The change from turbidites of distal aspect (0-260 m) to turbidites of proximal aspect (260-278 and 295-300 m) is similar to the changes seen at Bowmanstown. The passage from turbidites into shallow, agitated-water, pebbly sandstones is hard to interpret, but with the extensive bioturbation, depositional rates may have been low. The agitated marine deposits are pebbly sandstones which are hard to assign to a specific depositional environment.

FIELD TRIP SUGGESTIONS

Regardless of the time available, it is very strongly recommended that sections in the Susquehanna Valley area be visited *before* the Lehigh Valley area.

The turbidite part of the section is well displayed at Girtys Notch and Shamokin Dam, with microdetails of sedimentary structures better exposed at Shamokin Dam. The shaly upper part of the turbidite section is well displayed at Girtys Notch (340-445 m) and Newport (130-160 m). In the east, the transition from distal to proximal turbidites can be seen at Bowmanstown.

The most easily understood transition from turbidites to nonmarine sediments is exposed at Newport, on a quiet road. The Girtys Notch section is also well exposed, but lacks the slump, and is on a very busy road. At Shamokin Dam, the two "anomalous" sandstone bodies in the transitional part of the section should spark an argument about what is, or is not, turbidite. The very short transition in the east can easily be located at Bowmanstown by working downward through the quartzitic sandstone body from the 40 mph sign. The transition can also be admired from the top of the bank on the opposite side of the road, where one can look "down into the basin" and see proximal turbidites, and "onto the floodplain" and see red siltstones.

The very rapid passage from transitional sediments into nonmarine siltstones is superbly displayed at Newport and Shamokin Dam. Both of the sections lack any evidence of nearshore or coastal sand bodies. The Irish Valley motifs are well displayed at Girtys Notch (especially 510-590 m), Newport (210-240 m) and Rupert (especially 290-340 m). In the east, the one motif occurs close to the 40 mph sign.

ONE-DAY EXCURSION

Drive to Newport and park at south end of section (just before Highway Department yard). Walk up section through the turbidites, slump slope shales and motifs, ending at Newport Bridge. Allow about 2-3 hours. Drive to Bowmanstown (about 100 miles, allow 2¼ hours) via U.S. 22/322 to the east side of the Susquehanna, U.S. 22 and/or I 78 east to meet the N E extension of the Pennsylvania Turnpike, north on the Turnpike to the Mahoning Valley (Lehighton) exit, and south on Pennsylvania Highway 248. Take the Parryville exit and park. Walk downsection (south) to *beyond* the Lehighton - Jim Thorpe road sign to see the relatively distal turbidites. Work back upsection to the end (allow 2-3 hours).

TWO-DAY EXCURSION

Day 1. Begin at Girtys Notch; locate the roadside rest on U.S. 11/15, and then drive south about one-half mile to the first big bluff. Stop near south end to examine distal turbidites. Drive on past covered section and park at foot of ramp (350 m on section, by Pole 619). Walk up section at least as far as 660 m, and observe shaling-out of turbidite section, slope shales, one nearshore sandstone body, and a succession of Irish Valley motifs. It is then well worth looking at the section 710-830 m, where alluvial plain fining-upward sequences occur within the nonmarine portions of the Irish Valley motifs. Allow entire morning; Trail Diner just south of the section is a handy eating place.

Drive south on U.S. 11/15, and NW on U.S. 22/322, to take Newport exit. Turn left at Newport Bridge crossroads, and park near Highway Department yard (see 1-day excursion). Walk up section as far as the crossroads, and allow 2 hours.

Drive to Shamokin Dam (west of Sunbury) via U.S. 22/322 to Amith Hall, and north on U.S. 11/15 to the traffic circle at Shamokin Dam. Continue north on U.S. 11, under first railroad bridge, for about one-half mile. Park near second (Reading) railroad bridge (allow 1 hour for this drive). Walk up small track on north side of bridge to outcrop on Reading railroad (no through trains, but some switching). Turn south, locate slump (426-430 m), and walk up section to end of outcrop. Good exposures of slump, turbidites, "anomalous" sandstones, 2-m marine-nonmarine transition, and long marine section above first rootlets.

Examine scree below overhang for good specimens of desiccation cracks, trace fossils and rootlets.

Eat and sleep at Shamokin Dam – "motel row" starts just south of the traffic circle.

Day 2. For good exposures of turbidite details return to the Reading railroad section, but park just north of the traffic circle on U.S. 11. Scramble up to the railroad tracks, and walk up-section. Return briefly to top of section for photos (sun is on rocks only in the morning); allow up to 2 hours.

Continue north on U.S. 11 to Rupert, taking Pennsylvania Highway 42 S just before Bloomsburg (this exit was being reconstructed in 1970). Park about one-half mile south of Rupert station, in roadside rest (allow 45 minutes to drive). Walk quickly up-section and concentrate on section 300-420 m, which has good exposures of very thin motifs and two unusually thick sandstone bodies. The south end of the exposure, from 490 m upward, is worth visiting to see well-exposed fluvial fining-upward cycles in the Buddys Run Member. Allow about 2 hours at Rupert.

Drive to Bowmanstown, and follow guide for the one-day excursion. Quickest route is via I 80 and south on N E extension of Turnpike. Highway 93, via Hazelton and Jim Thorpe, is very scenic in places.

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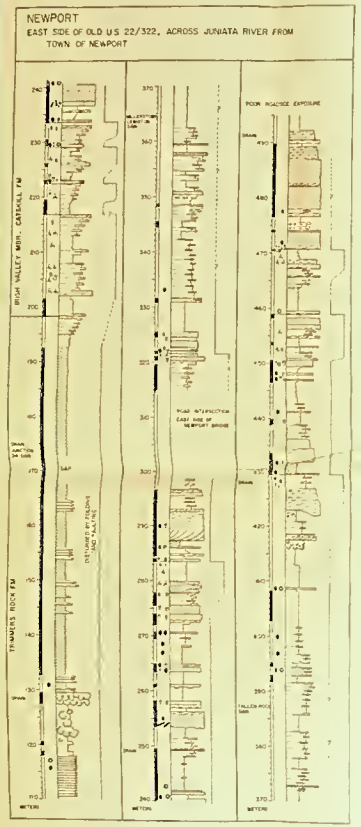
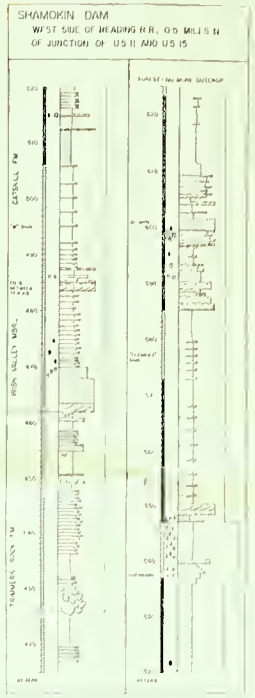
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

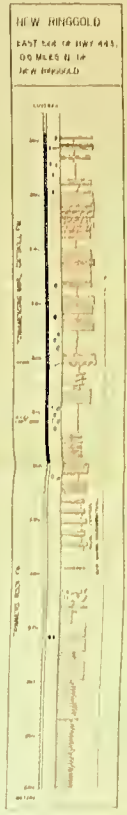
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

GENERAL GEOLOGY REPORT 64, PLATE 1


NEWPORT
EAST SIDE OF OLD U.S 22/322, ACROSS JUNIATA RIVER FROM TOWN OF NEWPORT
RIDGE VALLEY MBR., CATSKILL FM
TRIMMERS ROCK FM
ROAD INTERSECTION EAST SIDE OF NEWPORT BRIDGE
ROCK INCLUDE EXPOSURE
METERS

GIRTYS NOTCH
WEST SIDE OF U.S 11/15, 3 MILES N OF NEW BUFFALO, 17 MILES N OF HARRISBURG
RIDGE VALLEY MBR., CATSKILL FM
TRIMMERS ROCK FM
SECTION DISTURBED BY BLASTING
METERS


SHAMOKIN DAM
WEST SIDE OF READING R.R., 0.6 MILES N OF JUNCTION OF U.S 11 AND U.S 15
RIDGE VALLEY MBR., CATSKILL FM
TRIMMERS ROCK FM
DUNCANNON MBR.



UPPER DEVONIAN STRATIGRAPHIC SECTIONS

BY

ROGER G. WALKER

1972

LEGEND